

THE IMPACT OF BODY FAT PERCENTAGE ON CARDIORESPIRATORY FITNESS AMONG YOUNG ADULTS IN A MEDICAL COLLEGE OF NEPAL

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ABSTRACT

Cardiorespiratory fitness, reflected by VO_2max , indicates the body's capacity to utilize oxygen during exercise and is influenced by factors such as age, sex, genetics, and body composition. Body adiposity index serves as an estimate of body fat percentage and is inversely associated with aerobic capacity. Considering rising cardiovascular risk among young adults due to lifestyle changes, this study aimed to examine the relationship between body fat percentage and cardiorespiratory fitness. This cross-sectional study included 105 undergraduate students (56 males, 49 females), aged 18–25 years from Kathmandu University School of Medical Sciences, Dhulikhel, Kavre, were selected through convenience sampling. Anthropometric measurements, including height, weight, and hip circumference were recorded. Body mass index and body adiposity index were calculated. VO_2max was estimated indirectly using the Queen's College Step Test protocol. Male participants had a mean $\pm$ SD VO_2max of 45.04 ± 6.53 ml/kg/min and a mean $\pm$ SD body adiposity index of 24.31 ± 4.21 , whereas females showed a mean $\pm$ SD VO_2max of 33.99 ± 3.64 ml/kg/min and a mean $\pm$ SD body fat percentage of 30.99 ± 5.03 . VO_2max was significantly higher in males, while body fat percentage was significantly higher in females ($p < 0.001$). A significant moderate negative correlation was observed between VO_2max and body fat percentage ($r = -0.522$, $p < 0.001$). A significant moderate inverse relationship was observed between VO_2max and body fat percentage, indicating that higher adiposity is associated with lower aerobic capacity.

KEYWORDS

Cardio respiratory fitness, VO_2max , Step test

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INTRODUCTION

Excess body fat is a marker of obesity. Obesity is associated with an increased risk of developing cardiovascular diseases, but this risk appears to vary depending on levels of cardiorespiratory fitness.¹ Cardiorespiratory fitness (CRF) refers to the body's ability to transport and utilize oxygen in the skeletal muscles to produce energy during physical activity. Peak alveolar oxygen uptake (VO_2max) is commonly used in research to assess maximal aerobic capacity.² In a laboratory setting VO_2max can be measured by using equipment such as a treadmill, cycle ergometer, or stepping tools like the Queen's College Step Test and the Harvard Step Test.³

VO_2max is influenced by several factors, including genetics, levels of physical activity, gender, age and body composition.⁴ An inverse relationship exists between body mass index (BMI) and VO_2max in both males and females, meaning that higher BMI is generally associated with lower cardiorespiratory fitness.¹ A reduction in maximal oxygen consumption (VO_2max) and an increase in fat mass can serve as early indicators of cardiovascular disease risk.⁵ Body adiposity can be measured by using body mass index (BMI), body adiposity index (BAI), waist circumference (WC) and waist hip ratio (WHR).⁶ Previous study showed that in both genders, body fat percentage (BF%) and WC are better indices that reflect fat distribution than BMI, which is widely used index. Also, the individual with less fat mass has better cardiorespiratory fitness as compared to those with high fat mass. The authors found significant decrease in VO_2max in participants with high fat mass.⁵

Now a days, the lifestyle of the younger population has become sedentary due to prolonged desk work, limited physical activity, internet-based gaming, and the consumption of fast food, all of which contribute to obesity. Thus, the present study was conducted to assess the impact of body fat percentage on cardiorespiratory fitness among undergraduate students in a medical college of Nepal.

MATERIALS AND METHODS

This was a cross-sectional observational study, carried out among apparently healthy male and female medical students, 18 to 25 years of age, from Kathmandu University School of Medical Sciences, Dhulikhel, Kavre in the laboratory of the Department of Physiology. Sample was collected from October 2025 to February 2026 after obtaining ethical clearance from

Institutional Review Committee, Kathmandu University School of Medical Sciences (Ref. No.: 211/25). Participants having any acute or chronic illness, cardiovascular disease, respiratory disease and joint disease were excluded from the study. Sample size was calculated based on the study by Nabi *et al.*⁷

$$n = 2(Z_{\alpha} + Z_{1-\beta})^2 \sigma^2 / \Delta^2$$

Standard deviation $\sigma = 8.96$,

Estimated effect size $\Delta = 7.81$,

$Z_{\alpha} = 1.96$ (at 5% level of significance),

$Z_{1-\beta} = 0.8416$ (at power of 80%).

The desired sample size was 42 participants. By expecting a 25% dropout (or non-response) rate, total adjusted minimum sample size was 56.

Thus 56 male participants and 49 female participants were enrolled in the present study using convenience sampling technique who met inclusive criteria (healthy, age between 18-25 years, not having any acute or chronic illness, cardiovascular disease, respiratory disease and joint disease). Then the procedure was explained to the participants and written informed consent obtained from them.

The participants were instructed not to indulge in any activities and not to have heavy meal/tea/coffee at least two hours prior. Anthropometric measurements such as height, weight and hip circumferences was recorded. Participant were asked to stand erect against the wall with heels together and touching the wall, and head held in upright position. Height was measured without shoes to the nearest centimeter using a ruler attached to the wall. Weight was measured with minimum cloths and no footwear on a standardized weighing machine marked from 0 to 130 kg and was recorded to the nearest 0.5 kg. The hip circumference was measured with a measuring tape to the widest point on the greater trochanter. The body adiposity index (BAI), a direct estimate of body fat percentage was calculated as $[\text{hip circumference (CM)} / (\text{height (M)})^{1.5}] - 18$.⁸ BAI results were interpreted as low body fat: <8% (male); <21% (female), healthy body fat: 8-21% (male); 21%–33% (female), over weight body fat: 21-26% (male); 33–39% (female), and obese body fat: $\geq 27\%$ (male); $\geq 40\%$ (female).

Then the VO_2max was estimated indirectly by following the protocol of Queen's College Step Test (QCST) method. Individuals stepped to a four-step cadence ("up-up-down-down") using a tool of 16.25 inches height (height of standard

gymnasium bleachers). Stepping was done for a total duration of three minutes at the rate of 24 steps up per minute set by a metronome at a setting of 96 beats per minute for males and 22 steps up per minute set by a metronome at a setting of 88 beats for females. Stepping was started after a brief demonstration and practice period. After completion of stepping, radial pulse was measured for 15 seconds. The 15 seconds pulse rate (PR) was converted into beats per minute ($PR \times 4$) and following equation was used to calculate $VO_2\max$.³ For males: $VO_2\max = 111.33 - [0.42 \times \text{pulse rate (beats/min)}]$ [ml/Kg/min] For females: $VO_2\max = 65.81 - [0.1847 \times \text{pulse rate (beats/min)}]$ [ml/Kg/min]. Finally, the level of CRF was categorized according to their $VO_2\max$ level in ml/kg/min as excellent (male ≥ 53 ; female ≥ 49), good (male 44-52.9; female 39-48.9), average (male 34-43.9; female 31-38.9), fair (male 25-33.9; female 24-30.9) and poor (male ≤ 24.9 ; female ≤ 23.9).^{9,10}

The data was collected, compiled and analyzed using SPSS-22. Analysis was done using descriptive statistics like frequency, percentage, mean and standard deviation, and inferential statistics like student's t-test and

Pearson correlation analysis. A p value <0.05 was considered significant.

RESULTS

The study was conducted among 105 undergraduate medical students, comprising 56 male and 49 female participants. The mean values for age, height, weight, and hip circumference are presented in Table 1. The mean baseline as well as recovery heart rate was higher in female participants compared to male participants. However, calculated $VO_2\max$ for male participants were higher than female participants. The mean body adiposity index (BAI) was higher in female participants compared to male participants.

When the study participants were categorized according to the fitness scale, it was observed that the majority of male participants fell within the average and good fitness categories, while the smallest proportion was classified in the excellent category. Similarly, among female participants, most individuals were distributed within the average fitness categories (Table 2).

Table 1: The anthropometric data of both groups

Parameters	Total (n=105) Mean $\pm$ SD	Male (n=56, 53.3%) Mean $\pm$ SD	Female (n=49, 46.7%) Mean $\pm$ SD	p value
Age (Years)	20.33 $\pm$ 1.34	20.58 $\pm$ 1.46	20.04 $\pm$ 1.13	0.036
Height (m)	1.64 $\pm$ 0.09	1.71 $\pm$ 0.05	1.56 $\pm$ 0.06	<0.001
Weight (Kg)	62.26 $\pm$ 10.91	66.76 $\pm$ 10.14	57.12 $\pm$ 9.46	<0.001
Hip circumference (cm)	95.21 $\pm$ 9.10	94.59 $\pm$ 8.14	95.92 $\pm$ 10.13	0.458
Baseline heart rate (beats/min)	71.09 $\pm$ 5.78	69.41 $\pm$ 5.12	73.02 $\pm$ 5.94	0.001
Recovery heart rate (beats/min)	164.56 $\pm$ 18.97	157.82 $\pm$ 15.55	172.27 $\pm$ 19.73	<0.001
$VO_2\max$ (ml/kg/min)	39.88 $\pm$ 7.70	45.04 $\pm$ 6.53	33.99 $\pm$ 3.64	<0.001
BMI (Kg/m ²)	23.04 $\pm$ 3.66	22.85 $\pm$ 3.85	23.26 $\pm$ 3.44	0.563
BAI (%)	27.43 $\pm$ 5.68	24.31 $\pm$ 4.21	30.99 $\pm$ 5.03	<0.001

Kg: Kilogram, m: meter, cm: centimeter, min: minute, $VO_2\max$: maximal oxygen consumption, BAI: body adiposity index, BMI: body mass index, P <0.05 is significant

Table 2: Distribution of data based on $VO_2\max$ classification

Male		Female	
$VO_2\max$ categories	N (%)	$VO_2\max$ categories	N (%)
Poor (≤ 24.9)	0,0	Poor (≤ 23.9)	0,0
Fair (25 - 33.9)	0,0	Fair (45 - 30.9)	5 (10.2)
Average (34 - 43.9)	28 (50.0)	Average (31 - 38.9)	40 (81.6)
Good (44 - 52.9)	20 (35.7)	Good (39 - 48.9)	4(8.2)
Excellent (≥ 53)	8 (14.3)	Excellent (≥ 49)	0, 0
Total	56 (100)	Total	49 (100)

Values are number (percentage), $VO_2\max$: maximal oxygen consumption

Table 3: Gender wise distribution of body adiposity index

Fat %	Male (n = 56)		Female (n = 49)		p-value
	N (%)	(Mean±SD)	N (%)	(Mean±SD)	
Low fat (n=1)	0,0	0,0	1 (2.0)	15.65±0.00	
Normal fat (n = 41)	8 (14.30)	17.28±3.59	33 (67.3)	29.09±3.23	<0.001
Overweight fat (n=42)	29 (51.8)	23.56±1.63	13 (26.5)	35.33±1.97	<0.001
Obese fat (n=21)	19 (33.9)	28.43±2.05	2 (4.1)	41.74±1.90	<0.001

Values are number (percentage) or Mean±SD, P <0.05 is significant

Table 4: Correlation of different parameters with VO₂ max

Parameters	Total		Male		Female	
	r	p-value	r	p-value	r	p-value
Height	0.645	<0.001**	0.311	0.020*	0.058	0.692
Weight	0.239	0.014*	-0.172	0.204	-0.042	0.785
Hip circumference	-0.116	0.240	-0.204	0.132	0.076	0.602
BMI	-0.190	0.052	-0.275	0.040*	-0.093	0.526
BAI(%)	-0.522	<0.001**	-0.324	0.015*	0.045	0.760
Over weight fat	-0.733	<0.001**	-0.129	0.506	0.192	0.346
Obese fat	-0.404	0.070	0.004	0.988	-0.011	0.969

**Correlation is significant at the 0.01 level, *Correlation is significant at the 0.05 level

Out of the total 105 participants, 51.8% male participants and 26.5% female participants had overweight body fat percentage (>21- 26% for male and >33-39% for female) and 33.9% male and 4.1% female participants had obese fat percentage (>26% for male and >39% for female).

The results of the study demonstrated a negative correlation between VO₂max and BAI (r = -0.522, <0.001) and overweight body fat percentage (r = -0.733, <0.001). In contrast, a positive correlations were observed between VO₂max and height (r = 0.645) as well as weight (r = 0.239). No significant correlation was found between hip circumference and VO₂max. Negative correlation exists between VO₂max and BMI as well as BAI in male participants (Table 4).

DISCUSSION

Cardiorespiratory fitness estimates maximum oxygen consumption (VO₂max) during sustained exercise which varies with weight, adiposity, lean body mass, age, physical activity levels and gender.¹¹ The major findings of the present study demonstrated that the mean VO₂max was significantly higher in males compared to females (p <0.001), which is consistent with observations reported in previous studies.^{5,9,10,12} This gender based difference in VO₂max may be explained by several physiological factors such as body build, size of the chest, pulmonary ventilation,

diffusion across the pulmonary capillary membrane, cardiac output, and hemoglobin levels, as well as skeletal muscle blood flow.⁹ Furthermore, lower fitness in females is attributed to lower hemoglobin levels, differences in hormonal profiles, reduced muscle mass, higher body fat, and generally lower physical activity compared to males which may reduce their ability to transport oxygen to active muscles and consequently limit their VO₂max.¹²

The results of the present study indicate that 14.03% of male participants were classified in the excellent fitness category based on VO₂max values. In comparison, studies by Koju *et al.*⁹ and Prajapati *et al.*¹⁰ reported a higher proportion of male participants in the excellent fitness category, at 30% and 82.22%, respectively. Conversely, the proportion of male participants categorized as having average fitness in those studies was considerably lower (7.5% and 2.22%, respectively) than that observed in the present study. These differences may reflect variations in study populations, assessment methods, or lifestyle-related factors influencing cardiorespiratory fitness.⁵ Our study showed that none of female participants fell in the excellent fitness category but the majority (81.6%) were categorized within the average fitness level based on VO₂max values. Similar result was found by a previous study^{9,10} none of female participants belonged to excellent category. This distribution highlights a gender related difference in aerobic capacity, with males generally demonstrating higher VO₂max values than females.¹²

Our study demonstrate that $VO_2\text{max}$ has inverse relation with body adiposity index, this is consistent with Hanifah *et al*¹³ and Imboden *et al*.¹⁴ This endorses the common notion of reducing body fat for better fitness. In male participants, inverse relation between $VO_2\text{max}$ and BMI as well as BAI exists. One of the reasons may be the greater lean muscle mass present in individuals with lower body fat, which may contribute to enhanced exercise performance. Furthermore, previous studies have reported higher cardiorespiratory fitness (CRF) in lean individuals compared to their obese counterparts.¹⁵ In individuals with overweight or excess adiposity, oxygen delivery to working muscles may be impaired due to increased fat mass. Stevens *et al*¹⁶ reported that low cardiorespiratory fitness represents a stronger predictor of mortality than adiposity alone. Therefore, the maintenance

of cardiorespiratory fitness, alongside the prevention of excess fat accumulation, is critical for the long-term reduction of cardio-metabolic risk factors.

The present study concludes that there is a statistically significant higher mean $VO_2\text{max}$ in male participants compared to females, highlighting inherent sex based differences in aerobic capacity. Moreover, an inverse association was observed between body fat percentage and $VO_2\text{max}$ among young adults, indicating that higher levels of adiposity are linked to reduced cardiorespiratory fitness. These results emphasize the critical role of body composition in determining aerobic performance.

Conflict of Interest: None

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